ARMY RESEARCH LABORATORY

Effect of Solventless Bore Cleaning Device (SBCD) on Surface Finish and Contamination Transport in the M256 Gun Barrel

by Mark Bundy, James Garner, Gerald Garcia, Robert Baylor, Terry Marrs, Julius Pitts, and Bob Vanina

ARL-TR-3946 **September 2006**

NOTICES

Disclaimers

Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5066

ARL-TR-3946 **September 2006**

Effect of Solventless Bore Cleaning Device (SBCD) on Surface Finish and Contamination Transport in the M256 Gun Barrel

Mark Bundy and James Garner
Weapons and Materials Research Directorate, ARL

Gerald Garcia, Robert Baylor, Terry Marrs, and Julius Pitts
U.S. Army Aberdeen Test Center, APG

Bob Vanina
ARDEC, Benet Laboratories, Watervliet, NY

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
September 2006

2. REPORT TYPE
Final

3. DATES COVERED (From - To)
2006

4. TITLE AND SUBTITLE
Effect of Solventless Bore Cleaning Device (SBCD) on Surface Finish and Contamination Transport in the M256 Gun Barrel

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Mark Bundy, James Garner,* Gerald Garcia,* Robert Baylor,* Terry Marrs,* Julius Pitts,* and Bob Vanina†

5d. PROJECT NUMBER
AH80

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
ATTN: AMSRD-ARL-WM-BC
Aberdeen Proving Ground, MD 21005-5066

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TR-3946

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
*U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD 21005-5059
†ARDEC, Benet Laboratories, Watervliet, NY 12182

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
A new solventless bore cleaning technique, marketed by GI Industries, is currently under review by the U.S. Army Research Laboratory, Benet Laboratory, and the Aberdeen Test Center. Previous studies have shown that this new cleaning system is efficient at removing propellant residue/glaze without producing any measurable bore wear. This report speaks to both the subtle question of whether or not this new method of cleaning roughens the surface finish; but more importantly, it addresses health and safety issues if the process is applied to barrels having fired depleted uranium rounds. As reported herein, the surface finish is unchanged by the cleaning process. Furthermore, a pre- and post-cleaned radiological survey of a contaminated barrel showed no transport of radioactivity to the cleaning device components, or within the evacuated cleaning dust. The broader implications of the later test are that depleted uranium contamination, when present, lies within the barrel metal, which is not removed in the cleaning process.

15. SUBJECT TERMS
gun, barrel, cleaning, DU radiation, contamination, surface finish

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Mark Bundy
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** (*Include area code*)
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL	14	410-278-3815

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Contents

List of Figures

List if Tables

1. Introduction and Background Studies

The U.S. Army Research Laboratory (ARL) and Aberdeen Test Center (ATC) have designed and conducted bore cleaning studies[1] on a commercially sold (GI Industries Inc., Monroe, CT) solventless barrel cleaning device (SBCD) (figure 1). Bore cleaning takes place by manually guiding a spinning brush on the end of a flexible drive shaft up and down the bore for 15–20 min. The brush itself is made from ceramic (silicon carbide) impregnated organic resin matrix spheres or strands which abrade away, along with the bore residues, during the course of cleaning. The combined brush and bore residue can be collected using a vacuum attachment at the muzzle, as illustrated in figure 2.

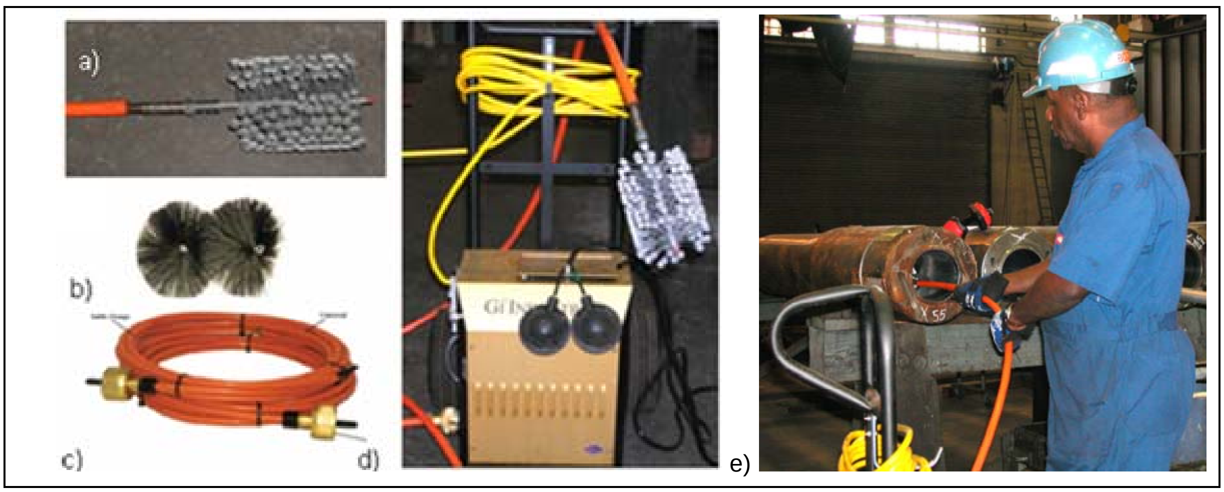

Figure 1. GI industries bore cleaning (a) ball brush, (b) swab brush, (c) flexible steel drive shaft, (d) foot-peddle-controlled electric drive motor, (e) in operation.

Dimensional inspection of barrels cleaned with the SBCD showed no wear of the chrome or exposed steel substrate.[1] Furthermore, an elemental material analysis (using scanning electron microscopy with dispersive x-ray spectroscopy SEM/EDS) of the evacuated cleaning dust[2] did not reveal any chrome or substrate gun steel (from existing chrome chip sites) that could be attributed to brush-induced bore wear.

Although wear tests failed to show any measurable level of bore erosion, two additional wear-related tests were conducted, and the results are reported in the following sections.

[1]Bundy, M.; Pitts, J.; Baylor, R.; Doss, J.; Karschner, C. *Solventless Bore Cleaning System for M256 Tank Cannon*; ARL-TR-3650; U.S. Army Research Laboratory: Aberdeen Proving Ground, MD, September 2005.

[2]Vanina, B. M256 Cleaning Residue. Memorandum from AMSRD-AAR-AEW-PC, Benet Laboratories: Watervliet, NY, May 2006.

Figure 2. Vacuum fixture designed to remove abraded brush and bore surface residue during cleaning.

2. Post-Cleaned SBCD Surface Finish

Though the surface finish may appear (figure 3) roughened by the SBCD cleaning process, a surface finish measurement (using a Handysurf E-21A surface texture analyzer, manufactured by Sheffield Measurement) indicates (table 1) the smoothness is on par with that of a new barrel.* Hence the SBCD device does not measurably change the barrel's surface finish.

3. Radiological Assessment of an SBCD-Cleaned DU-Contaminated Barrel

Because of its high mass density, depleted uranium (DU) is often used as a component in tactical long-rod penetrator designs, such as the M829 family of 120-mm kinetic energy (KE) rounds. On rare occasions, it is possible for trace amounts of DU particles to be left behind in the gun

*The M256 barrel drawing allows a 1.6-μm finish on the chrome bore.

Figure 3. Surface finish appearance after SBCD cleaning.

Table 1. Surface finish measurements.

M256 Barrel Condition and Serial No.	Surface Finish[a] (μm)
SBCD-cleaned 4247	0.31
New 11508	1.17
New 11512	1.60
New 11514	0.64
New 11515	0.31
New 11521	0.57

[a]Higher surface finish numbers are synonymous with a rougher texture.

bore (though a discussion of how this transpires is outside the scope of this report). Precisely where the DU contamination resides is not universally agreed upon—is it located in the surface "glaze," which would be removed in SBDC cleaning, or, is it located within the subsurface metal, and therefore unlikely to be removed by the SBCD cleaning process? To shed some light on this issue and determine the level of hazard that may exist, if any, a known-to-be radioactive barrel (serial no. 10799) was cleaned with the SBCD and the dust collected in a High-Efficiency Particulate Air (HEPA) filtered vacuum system.

The survey of the gun tube and cleaning system consisted of a radiation level meter survey and swipe sampling of the gun tube before and after the cleaning procedure, as well as swipe sampling performed on the cleaning head, vacuum, and dust collection bag after the cleaning procedure was completed.

The field radiation detection system was a calibrated Ludlum Model 3 field portable beta/gamma survey meter (serial no. 18383).* The Ludlum 3 is widely used in the radiation protection field to search for the presence of beta- and gamma-emitting radioactive contamination. DU emits both beta and gamma radiation, but is considered primarily a beta emitter. As such, the Ludlum 3 is well suited to field searches for the presence of DU contamination.

For all field surveys, ATC considers a radiation level of 0.05 millirem/hour (mR/hr) the threshold level to indicate a positive result for radioactive contamination of any item. A measured radiation level of 0.05 mR/hr represents twice the natural background radiation level which is typically in the range of 0.02–0.03 mR/hr. The twice-background level is a rule of thumb criteria commonly applied in environmental monitoring and analysis to indicate a true detection of a substance above a natural-background level.

Radiation can be fixed to, or removed from, an item. Removable contamination is considered potentially mobile in the environment, such as a dust that is coating an item that could be picked up by/transferred to anything that comes into contact with the item, including equipment/tools or personnel, thereby causing cross contamination. Fixed contamination means exactly that—the contamination is fixed or bonded to the source; it is a fundamental part of the item and is not available to be transferred to or cross contaminate another item.

To help determine if any contamination that may be present is fixed or removable, standard smear analysis was performed on the gun tube and cleaning equipment. In the swipe method, a cotton cloth smear is wiped over the surface of an item using moderate pressure. The swipe should come in contact with a total of 100 cm^2 surface area of an item. The swipe then undergoes laboratory analysis to look for the presence of radioactive contamination.

The lab instrumentation used for swipe analysis was a Tennelec, low-background, alpha/beta counting system. The Tennelec system is widely used in the radiation protection field to detect low levels of radioactive contamination. The Tennelec system undergoes weekly and daily quality control checks to assure the reliability of the results of all analyses.

Field surveys of the gun tube with the Ludlum 3 showed similar maximum radioactive contamination levels of 0.2 mR/hr at the muzzle end both before and after cleaning. Thus, the cleaning process produced no detectable change in the radiation levels measured within the tube. This lends evidence to the assertion that DU contamination is not in the glaze, as that was removed from the bore surface by the cleaning process, but rather, in the substrate bore metal that is not removed by the cleaning process.

---

*Source checks/functionality tests are performed every day a field survey instrument is used. All field instruments are maintained yearly in a certified calibration program. Calibration records are maintained on file for several years after the expiration of the year-long period.

Radiation levels from the swipe analysis of the tube, cleaning head, vacuum, and dust collection bin are listed in table 2. Laboratory analysis of the dry swipes is indicative of the raw number of disintegrations detected in the swipes, expressed as disintegrations per minute (dpm, the fundamental scientific unit of measure that defines the radioactivity of an item or source). For reference, the swipe results values in table 2 can be compared against ATC's (internal) evaluation criteria of 30.0 dpm/100 cm^2 alpha, and 100 dpm/100 cm^2 beta for the presence of removable contamination. This criteria is very conservative and was originally found in a standard issued by the former DARCOM. For comparison, the Department of Transportation criteria for the presence of removable contamination is 220 dpm/100 cm^2 alpha, and 2000 dpm/100 cm^2 beta.

Table 2. Radiation measurements.

Item	Alpha (dpm)	Beta (dpm)
Cleaning head stones	1.31 ± 1.39	4.29 ± 3.02
Vacuum dust bag	0.02 ± 0.03	–0.91 ± 2.03
Tube before cleaning	1.3 ± 1.39	5.2 ± 3.15
Tube after cleaning	15.15 ± 4.61	4.52 ± 3.49

In no instance was the removable contamination found on the swiped items at, or even near, ATC's conservative evaluation criteria. This is consistent with the Ludlum 3 results, which showed the source of DU contamination was still in the gun tube.

Hence, both the field survey and the laboratory radiation testing support the conclusion that the DU contamination is affixed/bonded to the bore metal and not removed by the SBCD. Equivalently, the contamination does not appear to be associated with the combustion products that are removed during the cleaning process, and the cleaning process is not aggressive enough to remove metal from the bore surface. Thus, these results suggest that there is little hazard from a radiation perspective to personnel operating the SBCD.

4. Conclusions

An SBCD, previously shown to provide effective cleaning with no detectable wear on the M256 smoothbore tank cannon, was further examined here for its effect on surface finish and for its potential to remove DU from a contaminated barrel. Test results showed the surface finish of an SBCD-cleaned barrel was comparable to a new barrel. In addition, a radiological survey showed the radiation levels of the SBCD components and evacuated cleaning dust were not above normal after cleaning a DU-contaminated barrel. Conversely, the well-above background radiation levels in the contaminated barrel were unchanged by the SBCD cleaning, indicating the DU contamination is fixed within the bore metal.

NO. OF COPIES	ORGANIZATION
1 (PDF ONLY)	DEFENSE TECHNICAL INFORMATION CTR DTIC OCA 8725 JOHN J KINGMAN RD STE 0944 FORT BELVOIR VA 22060-6218
1	US ARMY RSRCH DEV & ENGRG CMD SYSTEMS OF SYSTEMS INTEGRATION AMSRD SS T 6000 6TH ST STE 100 FORT BELVOIR VA 22060-5608
1	DIRECTOR US ARMY RESEARCH LAB IMNE ALC IMS 2800 POWDER MILL RD ADELPHI MD 20783-1197
3	DIRECTOR US ARMY RESEARCH LAB AMSRD ARL CI OK TL 2800 POWDER MILL RD ADELPHI MD 20783-1197

ABERDEEN PROVING GROUND

1	DIR USARL AMSRD ARL CI OK TP (BLDG 4600)

NO. OF COPIES	ORGANIZATION
3	DIR BENET LAB AMSTA AR CCB EA R COOLEY AMSTA AR CCB EC R VANINA AMSTA AR CCB QAC M MIZENKO WATERVLIET NY 12189-4050
2	COMMANDER WATERVLIET ARSENAL SMAWV CA R FLISZAR S DIAGOSTINO WATERVLIET NY 12189-4050
1	ABRAMS TANK SYS PEO ARMORED SYS MODERNIZATION SFAE GCS AB SW A HAVRILLA WARREN MI 48397-5000
1	OPM MAS SFAE AMO MAS LC BLDG 354 C CORDING PICATINNY ARSENAL NJ 07806
1	DIRECTORATE OF TRAINING DOCTRINE AND COMBAT DEV ATZK TDD ORSA POMEY RM 219 WING A BLDG 1467 RD AVE FORT KNOX KY 40121-5000
2	COMANDER TACOM – ROCK ISLAND AMSTA LC CAW G BIERI K CROOKS BLDG 104 E WING 2ND FL ROCK ISLAND IL 61299-5000
1	GI INDUSTRIES INC B GOOD 525 FAN HILL RD MONROE CT 06468

NO. OF COPIES	ORGANIZATION
	ABERDEEN PROVING GROUND
17	DIR USARL AMSRD ARL WM BC M BUNDY (8 CPS) J GARNER B GUIDOS P PLOSTINS J NEWILL D LYON B BURNS E SCHMIDT R COATES S D WILKERSON

INTENTIONALLY LEFT BLANK.